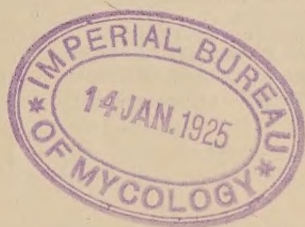


The Control of Bacterial Blight of Celery by Spraying and Dusting

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THE CONTROL OF BACTERIAL BLIGHT OF CELERY BY SPRAYING AND DUSTING

H. W. DYE AND A. G. NEWHALL

The value of the entire celery crop of the United States was nearly twelve million dollars in 1922. More than twenty thousand acres were devoted to its culture. The four principal celery-growing districts are in California, Michigan, New York, and Florida. These States keep American markets supplied throughout the entire year. New York State ranks third in the production of celery for the general market. The value of its crop is in the neighborhood of a million and a half dollars annually.

The extensive muck areas in western New York are admirably adapted to the cultivation of celery. Wayne County, the principal celery-producing section of the State, has an output of about two thousand cars annually. In many localities cold-storage facilities, many of which are owned and operated by the growers, give to New York the advantages of an unusually long shipping season. The variety grown almost exclusively in New York is the Golden Self Blanching. The seed is generally sown out of doors in beds or coldframes during April and May, and is transplanted to the fields the latter part of June. It is not an uncommon practice for the growers to obtain a crop of spinach or early lettuce from a field before setting it to celery.

PRINCIPAL CELERY TROUBLES

With intensive culture and repeated cropping, a number of serious celery troubles have become more or less thoroughly established in western New York. Two diseases are of major importance: bacterial blight, or leaf spot, caused by *Pseudomonas apii* Jagger, and late blight, caused by *Septoria apii* Rostr. In some seasons, early blight, caused by *Cercospora apii* Fr., also becomes very destructive in certain sections. A seedling root-rot caused by a species of *Fusarium* is also very common and is to be found both in the seedbeds and in the field for a few weeks after transplanting.

A number of insect injuries and diseases of minor importance occur more or less frequently. Black joint, caused by the feeding punctures of the tarnished plant bug, is common in dry seasons. A root-knot caused by nematode injury is occasional in seedbeds. In some seasons the carrot rust fly produces injuries on celery roots, which are followed by a destructive rot. Blackheart is a physiological disease that affects more particularly rapidly growing, early celery after a change in weather from

AUTHOR'S ACKNOWLEDGMENT. Acknowledgment is made to the Williamson Cooperative Vegetable Association, Inc., of Williamson, New York, whose support of a fellowship made these investigations possible; to the Niagara Sprayer Company, of Middleport, New York, for the loan of a power duster and for the gift of certain dust materials; and to the Rose Vegetable Association, of North Rose, New York, for its cooperation during the season of 1921.

a period of heavy rainfall to one of drought. The tips of the inner leaves "scald," turn brown, and may subsequently contract a bacterial soft rot. Blackheart is thought to be caused by too much or too little water, and also by excessive use of nitrogenous fertilizers.¹

LOSSES FROM CELERY BLIGHTS

An accurate estimate of the losses occasioned by celery diseases and pests is impossible. In some seasons it is not uncommon for entire fields to become so thoroughly infested by either bacterial or late blight, or both, as to be quite worthless. In the older celery sections, early blight also becomes very severe at times. Many growers have, at some time in their experience, had their plants so badly blighted that they plowed under entire fields. According to the best estimates obtainable, the bacterial blight alone caused a 5-per-cent loss in Michigan in 1918.² In 1920, in New York,³ the loss from this disease, "which was less severe than during 1919 and previous years," amounted to from 3 to 5 per cent. "About one-third of the fields were infested in amounts ranging from a trace to 100 per cent." It is probable that the combined losses from the three blights in New York State annually average from 10 to 20 per cent. With a crop having a farm value of \$1,500,000, this loss for New York State amounts to from \$150,000 to \$300,000 annually, most of which is entirely preventable.

The injury from blights is both quantitative and qualitative. It is direct and indirect. The loss of leaf area and the destruction of the outer leaf stalks reduce the yield directly. Blighted celery, moreover, is not likely to keep well in the field after being banked, particularly in wet weather, due to the attacks of soft-rot organisms, which find ready access through the lesions. For the same reason, such celery does not keep as well in storage and more quickly rots on being placed on the market after a period of storage. With these facts in mind, many buyers discriminate against celery in the field which shows much blight injury.

DESCRIPTION OF CELERY BLIGHTS

The general term "blight" or "rust" is used indiscriminately by growers to include the bacterial blight, or leaf spot, caused by *Pseudomonas apii*; the late blight, caused by *Septoria apii*; and the early blight, caused by *Cercospora apii*. Since the experiments recorded here were mainly on bacterial blight, it is important to distinguish these various diseases. Both the bacterial- and the late-blight spots are small, rusty brown in color, and with irregularly circular outlines. These spots may occur to the extent of several hundred on a single leaflet. Sometimes they coalesce and involve its entire surface. Bacterial blight and late blight may readily be distinguished by the early appearance of minute, black pycnidia in the centers of the late-blight spots. The bacterial-blight spots remain somewhat more reddish and more uniformly brown in color, with a slightly

¹ Winters, R. Y. Celery diseases. In Report of Assistant in Botany. Florida Agr. Exp. Sta. Rept. 1908:XCIX-CIV. 1908.

² U. S. Agr. Dept., Bur. Plant Indus., Plant Dis. Sur. Bul., Sup. 3:104-106. 1919.

³ U. S. Agr. Dept., Bur. Plant Indus., Plant Dis. Sur. Bul., Sup. 16:272-277. 1921.



FIGURE I. LATE BLIGHT OF CELERY, CAUSED BY *SEPTORIA APII* ROSTR.

The numerous minute, black pycnidia, which characterize this disease, appear in the upper part of the leaf

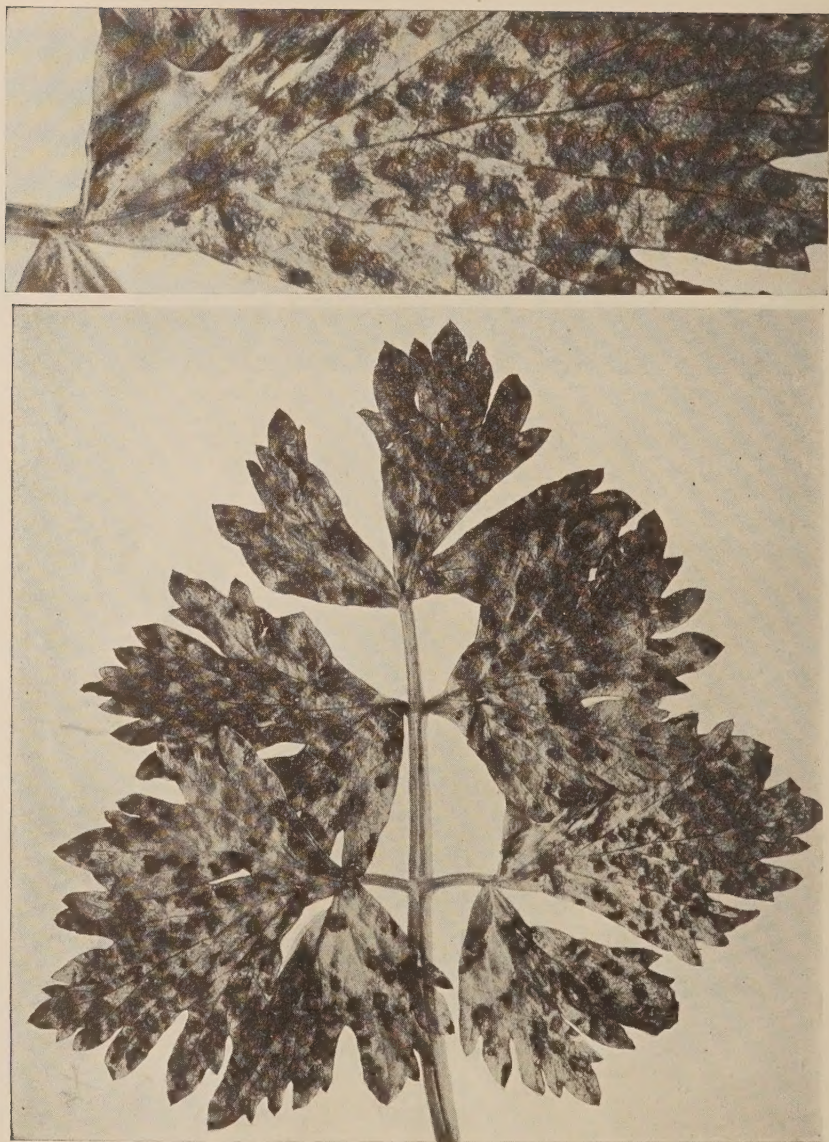


FIGURE 2. BACTERIAL BLIGHT OF CELERY, CAUSED BY *PSEUDOMONAS APII* JAGGER
These spots have no fruiting bodies, but are otherwise very similar to those of late blight. See also figure 8



FIGURE 3. EARLY BLIGHT OF CELERY, CAUSED BY CERCOSPORA APII FR.

This shows the large size of the spots, their dark margins, and the absence of conspicuous fruiting bodies

glistening surface, particularly in moist weather. The early blight is characterized by rather large, irregular spots, or blotches, often over one-half inch in diameter. They have an ashy gray color, and possess a definite, sometimes slightly raised and reddish margin. A very few large spots often involve an entire leaflet; and the fruiting bodies of the causal organism, when present, are very inconspicuous, consisting of numerous whitish tufts of spore-bearing conidiophores which may give the spot a somewhat ashen or velvety appearance. The bacterial blight and the early blight are confined, usually, though not invariably, to the leaves, whereas the late blight very frequently occurs also on the stems. Early blight is of less economic importance in New York. It occurs for the most part in the older celery-growing regions; even there, however, it rarely occasions severe injury. Late blight and bacterial blight, on the other hand, are more prevalent throughout the State.

BACTERIAL BLIGHT, OR LEAF SPOT

Occurrence

Bacterial blight, or leaf spot, was first described by Jagger,⁴ in 1918, in the Irondequoit district of western New York. It probably occurs very generally in the northern celery-growing districts, having been reported from Minnesota, Michigan, Indiana, and Pennsylvania, as well as from practically all the important celery sections of New York State.⁵

Varieties affected

Jagger found that the disease affects all varieties of celery commonly grown for market, including many strains of the Golden Self Blanching and also numerous varieties and strains of the so-called "green" types. He described the causal organism, after proving its pathogenicity, and gave the results of spraying experiments. It is a matter of common observation that the early green types are, in general, more resistant, as are also the newer strains of early Golden Self Blanching which have come into wide use since 1921. The apparent resistance of the early Golden Self Blanching varieties seems to be a case of disease escapement due to rapid, vigorous growth.

Sources of inoculum

It is not definitely known that the bacterial-blight pathogene is carried by the seed, but the first appearance of the disease is commonly in the seedbed, particularly in seasons of abundant rainfall during late May and June. It appears that the pathogene lives over in the soil, on trash from previously diseased plants. The disease has repeatedly been observed to be more abundant in seedbeds located on land which grew blighted celery the year before. However, it has also been observed in seedbeds located on new land on which celery had never been grown. Most growers fail to recognize the disease in the seedbed. Diseased seedlings which introduce the pathogene to the main field are undoubtedly of more importance than is commonly suspected. Many growers, who have raised their own

⁴ Jagger, Ivan C. Bacterial leafspot disease of celery. Journ. agr. research 21:185-188. 1921.

⁵ Letter from R. J. Haskell of the Office of Plant Disease Survey, Washington, D. C. 1923.

plants on clean soil and have bought additional plants to supplement their own from older celery-growing sections or from men who had neither sprayed nor dusted their seedbeds, have noted, on setting them out in the field, that blight appeared first and in greater abundance on the plants brought in from outside. (Seedbed dusting experiments are described on page 18.)

Secondary infections may take place in the field at any time after transplanting, and these usually continue throughout the season during periods of wet weather. The time required for new infections to make their appearance varies somewhat, but is in the neighborhood of from ten to fourteen days. Toward the last of the season it is common for the disease to spread rapidly, if the weather is rainy. In 1917, the number of spots in one field increased from an average of about 300 to the plant to an average of 1300 to the plant in three weeks during September. When the plants are nearly full-grown, they afford much more favorable opportunity for new infections to take place, since they then hold moisture longer each day. Likewise, at this stage of their growth there is more leaf surface exposed, and cultivation, if the plants are wet, becomes a means of wholesale mechanical inoculation up and down each row.

CONTROL OF BACTERIAL BLIGHT

Scope of investigations

The work of Jagger, in 1915 and 1916, demonstrated that bacterial blight could be held in check on the upland soils of the Irondequoit district by spraying with bordeaux mixture. He found, moreover, that lime-sulfur was not effective. In an attempt to check the losses which many growers of celery were experiencing from this disease in the muck areas of Wayne County, New York, the senior author initiated experiments, in 1917, at Williamson, New York. At that time most growers were practicing no control measures. Some were using a commercial bordeaux paste, and a very few were trying homemade bordeaux mixture. Many thought they could control blight by fertilizing with nitrate of soda. All desired more information on the effectiveness of various fungicides. With the development of fruit dusting, the question of extending this convenient method of disease control to the celery crop met with considerable interest. Accordingly, the chief objects of the work were, or afterwards became, to determine:

1. The effectiveness of homemade bordeaux mixture at different strengths, both with and without a sticker; and the comparative value of various sulfur fungicides.
2. The relative efficiency of certain bordeaux pastes and other proprietary compounds containing copper.
3. The relative effectiveness of copper-lime dust in comparison with liquid bordeaux mixture.

These investigations were continued over a period of six years (1917-1923). The last three years were devoted almost exclusively to a testing of copper-lime dust against the standard 5-5-50 bordeaux mixture and to the control of blight in the seedbed.

*Fungicides employed**Liquid fungicides*

The liquid fungicides listed below were all used at the rate of 100 gallons to the acre.

1. Bordeaux mixture, 5-5-50, 2-2-50, and 5-5-2-50. The 5-5-2-50 mixture contained 2 pounds of a resin-fish-oil soap sticker.

2. "Kiltone,"⁶ 20-50 and 8-50. These strengths corresponded to the two strengths of bordeaux mixture, with respect to their copper content. The 8-50 was the one recommended by the manufacturer at that time.

3. Lime-sulfur 1-25. This was made by diluting commercial concentrate testing 32 degrees Baumé.

Dry fungicides

Dry fungicides containing copper were used at the rate of 50 pounds to the acre. At this rate the copper-lime dust (paragraph 6) was comparable to 100 gallons of 5-5-50 bordeaux mixture, since each furnished 2.5 pounds of copper to the acre at each application. The dry bordeaux mixtures (paragraphs 4 and 5) at this rate supplied 1.8 pounds of copper to the acre at each application.

4. Dry bordeaux mixture,⁷ to which was added, as a filler, hydrated lime in the proportion of 17.2 pounds of bordeaux to 82.8 pounds of lime.

5. Dry bordeaux mixture, to which were added, as fillers, finely ground sulfur and hydrated lime in the proportion of 17.2 pounds of bordeaux, 30 pounds of sulfur, and 52.8 pounds of lime.

6. Copper-lime dust, made by mixing 15 pounds of dehydrated copper sulfate (33 per cent copper) with 85 pounds of hydrated lime. During one season a weaker mixture was tested (page 15).

Methods and machinery

The size and the shape of the plots varied somewhat. During the first three years, when only hand-operated dusters and sprayers were used, the plots consisted of single rows thirty yards in length. Each treatment was duplicated in different parts of the field, so that several materials could be conveniently tested in a moderate-sized area. In 1921, however, when only two fungicides were being compared, namely, 15-85 copper-lime dust and 5-5-50 bordeaux mixture, square plots were employed (figures 4 and 5). Replications were then from three to nine in number, according to the size of the field. In order to insure a satisfactory test of the materials employed, fields were chosen, as far as possible, in which blight was already uniformly present. When power outfits were used, entire fields of from two to seven acres were included in the experiments. The plots were then made four or eight rows wide, and were replicated from two to six times. A liberal number of check plots were always left. For the small plots, where hand-operated sprayers and dusters were used, the checks consisted of single rows between every two treated rows,

⁶ A proprietary bordeaux paste, containing 6 per cent copper, manufactured by the Kiltone Company, of Vineland, New Jersey.

⁷ A proprietary bordeaux powder, containing 22 per cent copper, manufactured by the Niagara Sprayer Company, of Middleport, New York.



FIGURE 4. A TYPICAL SERIES OF SINGLE-ROW PLOTS, ON WHICH ALL PRELIMINARY TESTS WERE MADE

These plots were thirty yards long. A hand-operated sprayer and duster, or "blower gun," was used*
Every third row was left untreated

except in 1921, when square check plots were left between every group of three treated plots (figures 4 and 5). When power machines were used, four-row check plots were left between each pair of eight-row treated plots. The first three years only hand-operated sprayers and dusters were used; but during the last two traction and power outfits were also employed, and the experimental plots were made correspondingly larger.

On the small plots the spraying was done with an E. C. Brown No. 9 "Auto Spray" three-gallon hand sprayer, and the dusting with a Niagara "blower gun," or hand-operated duster, of the crank type. On the larger plots, where traction and power outfits were used, the spraying was done with either a two-horse, traction, barrel sprayer of fifty-gallon capacity or a Decker spray rig of one-hundred-and-fifty-gallon capacity. These maintained pressures of one hundred and two hundred pounds, respectively. Both machines sprayed four rows at a time, one nozzle to the row. The dusting was done with a Niagara four-row power potato duster, 1919 model, equipped in 1920 with the new eight-nozzle "octopus" distributor. Certain improvements and adjustments were made, such as the substitution of a more powerful engine, a larger pulley, and wider nozzles of our own design, in order to get a more thorough and a more even distribution of the dust.

As far as possible, all machinery was adjusted to deliver 50 pounds of dust and 100 gallons of spray to the acre; and the dusts were mixed at such strengths that, when so used, an equivalent amount of copper, 2.5 pounds to the acre, would be applied by all (the dry bordeaux mixtures described in paragraphs 4 and 5, page 10, are exceptions). However, the aim throughout the season was always to keep the plants well covered,



FIGURE 5. A SERIES OF SQUARE, ONE-HUNDREDTH-ACRE PLOTS, ON WHICH THE FINAL COMPARISON OF COPPER-LIME DUST WITH BORDEAUX MIXTURE WAS MADE

A hand-driven duster and a hand-driven sprayer were used. Every third plot was left untreated, in addition to the central row of each sprayed plot. Part of each dusted plot was treated while the plants were still moist with dew

which meant that less than fifty pounds of dust were used in the first two applications and more in the later ones. At first the rows were dusted and sprayed from the top only; later in the season, from each side (figures 6, 7, and 10).

The number and the frequency of the applications varied somewhat, depending on the size of the plants at the beginning of the experiment, the rapidity of their growth, and the weather. From five to seven applications were made, the interval between them varying from five to



FIGURE 6. THE CROP DUSTER USED IN 1920

Two nozzles to each row were employed after the second application, and are now a part of the standard equipment of this type of crop duster. (Figures 7 and 10)

thirteen days. The first part of the morning was chosen for dusting, whenever possible, since the atmospheric conditions were then most favorable.

The method of determining the relative values of the different treatments was uniform throughout all the tests. The total number of blight



FIGURE 7. DUSTING CELERY AT 6 O'CLOCK IN THE MORNING WITH AN EIGHT-NOZZLE, FOUR-ROW, POWER CROP DUSTER

This shows how the dust drifts across the plants, completely enveloping them for a considerable time

spots on each of ten plants in each replication was counted, and from these sums the average number of spots to the plant was calculated for each plot. No attempt was made to select individuals, but a block of five adjacent plants was chosen at random in two places in the row. Counting was confined to the central rows of each plot, one or two outside rows always being discarded.

The yields from the plots were obtained by digging blocks of ten plants each from the central row or rows of each plot, weighing, trimming as for packing, and re-weighing. In the trimming process which western New York growers commonly practice, the outer blighted leaves are removed in the field at the time of harvesting. Weighing the plants before and after trimming thus gave an index of the relative total losses in yield of marketable celery due to uncontrolled blight, under the different treatments. Hence a fair estimate of the effectiveness of the treatments could be calculated and expressed in terms of net yields to the acre. In two instances, larger numbers of plants were employed in determining the yields.

Experimental results

Bordeaux mixture

Homemade bordeaux mixture 5-5-50, in a total of ten experiments covering a period of four years, gave an average reduction of blight, over that of the untreated plots, of 92 per cent. It was the best liquid fungicide used. This is one of the few instances on record of perfectly satisfactory control of a bacterial disease by means of spraying. The weaker mixture, 2-2-50, in the same ten experiments, reduced the blight 78 per cent and was not, on the whole, satisfactory. Although in a season of mild infestation a 2-2-50 or a 3-3-50 mixture might hold the disease in check, such strengths are not recommended. Resin-fish-oil soap added to the 5-5-50 mixture gave no better control, reducing blight 92 per cent in the eight experiments in which it was employed. The spray adhered to the plants much longer, however, giving them the appearance of being more thoroughly covered after the third application. The resin-fish-oil soap may have acted as a spreader, and thus might have made the spray go farther, but no tests of this property were conducted. It is an excellent material to make spray stick to such smooth leaves as celery, and is easy to use, but it is evidently of little or no value in the control of blight.

Commercial bordeaux paste (Kiltone)

The results of nine experiments, conducted over a period of four years, demonstrated that, even when used at equivalent strengths with respect to copper content, Kiltone did not give as good control as did homemade bordeaux mixture. The 20-50 Kiltone reduced the blight 82 per cent, while 5-5-50 bordeaux mixture reduced it 92 per cent. Similarly, the weaker mixtures, 8-50 Kiltone and 2-2-50 bordeaux mixture, gave controls of 69 and 78 per cent, respectively. The appearance of the plants several days after spraying indicated that the Kiltone was more easily washed from the leaves by rain. Homemade bordeaux mixture,

furthermore, remained in suspension longer, thus requiring less continuous agitation.

Lime-sulfur solution and dusting sulfur

In spite of the success achieved with sulfur in the control of fruit diseases, it proved worthless on celery. Lime-sulfur solution 1-25 and dusting sulfur were both tried during two seasons. In five experiments they gave no consistent control of blight, plots treated with them averaging, respectively, only 19 and 16 per cent better than did the untreated plots. In some instances the sulfur-treated plants had more blight than did the untreated plants, and even showed slight traces of fungicide injury. In this respect these results are in accord with those obtained by Jagger.

Dry bordeaux with sulfur and with lime as fillers

Two separate fillers were mixed with the proprietary bordeaux powder to reduce its copper concentration. As noted on page 10, these two dusts supplied only about two-thirds as much copper to the acre at each application as the other fungicides used in these experiments. Nevertheless, they were compared with 5-5-50 bordeaux mixture in eight experiments over a period of three seasons. The first mixture reduced the blight 67 per cent; the second 30 per cent; while the liquid spray reduced it 92 per cent. The presence of sulfur reduced the efficiency of the dust repeatedly. These dusts, therefore, were discarded.

In one experiment in which another commercial powdered-bordeaux mixture plus lime was used in a four-row power potato duster, fairly satisfactory control was obtained. The copper content of this dust was equivalent to that of 15-85 copper-lime. An 11-per-cent increase in yield was calculated after six applications, which amounted to 66 crates to the acre increase over the yield of the untreated plots.

Copper-lime dust

With the complete failure of sulfur, both as liquid lime-sulfur solution and as a dust, together with the success from the copper compounds and the popularity of the copper-lime dusts in the control of certain fruit diseases in some places, it seemed likely that a copper-lime dust would combine the features of an efficient fungicide and one much more convenient to use than the liquid bordeaux mixture. Accordingly, in 1919 two strengths were tried out on four farms. The limit of safety in the matter of concentration not being known, the mixtures were made up rather weak. The 8-92 copper-lime dust reduced the blight that year, in four experiments, on the average, 72 per cent. The 12-88 mixture reduced it 74 per cent, while the standard 5-5-50 bordeaux reduced it 94 per cent. The next season, 1920, 15-85 copper-lime dust was tested, and all subsequent experiments were made with this strength. When made with monohydrated copper sulfate containing 33 per cent copper and used at the rate of 50 pounds of dust to the acre, the same amount of copper is applied as is contained in 100 gallons of 5-5-50 bordeaux mixture, namely, 2.5 pounds to the acre. In five experiments with hand-

operated machines, covering the years of 1920 and 1921, the liquid Bordeaux mixture reduced blight 79 per cent and the copper-lime dust reduced it 78 per cent. The average control in five other experiments, where either power or traction machines were used, was 84 per cent and 86 per cent, respectively, for spray and for dust.

In order to illustrate the methods employed in the final testing of these two best fungicides, and also to show the uniformity of blight development throughout a series of similarly treated plots, the data obtained on two of the farms in 1921 are given in more detail in tables 1 and 2. These data have been selected as the most representative of all that were obtained. As seen in the photograph of the smaller series of plots on which hand-operated machines were used (figure 5), each spray and dust plot was seven rows in width, square, and contained one one-hundredth of an acre. Each treatment was replicated nine times, and check plots were distributed one between each group of three treated plots. In addition to the square check plots, the central row of each sprayed plot was left untreated. The relative efficiency of these two types of checks is brought out in the counts shown in table 1. To insure against mistakes in applying the materials, cords were stretched between the plots before every application.

From the figures given in tables 3 and 4, it is apparent that, with both hand-operated and power machines, the dust consistently controlled the bacterial blight as well as the spray did, the differences being insignificant.

Dusting wet and dry foliage

It was commonly believed that dusting while the dew was still on the plants would give a coating which would adhere better, and that there would be less loss from wind. Therefore, the dust plots on two farms were all divided into two parts (tables 5 and 6). Half of each plot was then dusted between 6 and 8 o'clock in the morning. If the night had been cloudy or slightly windy and there was no dew, the entire plot was dusted at one time.

The results of one season's experiments are indicative, as far as they go, that the practice of dusting while the plants are moist is a good one. It was not always possible to select mornings when there was a heavy dew, particularly when there was dusting to be done nearly every morning. Partly by chance and partly by design, five of the six mornings on which the Tuttle and Russell plots received applications were mornings when there was a fairly heavy dew. This was fortunate, since the largest number of replications, eight in number, were made there (table 5, figure 5). With only one exception out of the eight plots, there was less blight development on the plants which were dusted when still moist (table 5). Somewhat similar, though much less significant, results were obtained in one other series of three plots on the Glenn Beach farm (table 6), where the applications, in part at least, happened to be made on mornings when there was considerable dew on the plants. Again with one exception, blight seemed to be held in check better by dusting while the plants were still moist with dew.

It was evident on both farms, after the third application, that the plants so treated retained a heavier coating of fungicide from one application to the next. Both from observation in the field during the season and from careful counts at the end of the season, therefore, it is apparent that dusting while the plants are moist with dew gives a superior coating and a better blight control.

CONTROL OF LATE BLIGHT

In none of the experimental fields was early blight present in sufficient amounts to permit comparison between the effectiveness of one fungicide and another. In most seasons it was absent entirely, or occurred only as a trace. Late blight, however, developed, in a few instances, to a sufficient extent to warrant making counts of the number of spots on sprayed, dusted, and untreated plots. In one experiment they amounted to an average of 1258 spots to the plant on the untreated plots and 127 to the plant on those sprayed with 5-5-50 bordeaux mixture, a reduction in blight of 89 per cent. Here an increase in yield of 38 per cent, amounting to 123 crates an acre, was obtained from six applications of bordeaux mixture. In another experiment, five applications of bordeaux mixture gave a 91-per-cent reduction of late blight and an increase in yield of 12 per cent, amounting to 73 crates an acre. In the same field, seven applications of 15-85 copper-lime dust controlled the disease to the extent of 93 per cent, and an increase in yield of 23 per cent, amounting to 136 crates an acre, was obtained.

There is no doubt that, under average New York conditions, late blight can be controlled with bordeaux mixture. It seems very probable that dust will give equally satisfactory results, provided applications are made early enough and that the plants are kept thoroughly covered. Under abnormal conditions, the material that will give the best results will doubtless be the one which can be most easily applied at the most opportune time. The advantage of easier and speedier preparation and application lies with the dust. In wet seasons it is probable that a light dusting machine which permits light but more frequent applications of dust would give greater satisfaction than a heavier spray rig which could not be used at all as long as the muck remained wet.

In the summer of 1922, the senior author visited a large number of growers who were using four-row power dusting machines and a 20-80 copper-lime dust. The season was very favorable for late blight, which was unusually abundant. The disease was being fairly satisfactorily held in check by careful growers who had commenced early and made timely applications. The amount used was 25 to 35 pounds to the acre at each application, and two applications were made at three- or four-day intervals where blight seemed to be spreading as a result of wet weather.

Late blight is more difficult to control after it has become established than is the bacterial blight, according to our field observations. This is probably due to the different habits of the two pathogenes concerned. Thomas⁸ has pointed out that in late blight, caused by *Septoria apii*, the

⁸ Thomas, H. E. The relation of the health of the host and other factors to infection of *Apium graveolens* by *Septoria apii*. Torrey Bot. Club. Bul. 48:1-29. 1921.

younger, actively growing leaves are more readily attacked than are the more mature ones. But according to our observations, the opposite is true in the case of bacterial blight caused by *Pseudomonas apii*. Here the outside, mature leaves near the ground apparently are the most susceptible. Since celery makes its most vigorous growth in the latter half of the season, during which time many leaves unfold and reach almost their full size in but four or five days, it is obvious that to keep this expanding growth protected against late blight is more difficult than to keep the outer full-grown leaves protected against bacterial blight. The problem is complicated further by the fact that, as the plants increase in size and number of stalks, the inner, expanding leaves are more effectively shielded by the outer ones from a direct application of any fungicide. These two facts point to the great importance of commencing protective measures early in order to control late blight. It explains, also, why some growers have failed to obtain good control during the latter part of wet seasons with applications made at seven- to ten-day intervals, such intervals being too long to give adequate protection to the young growth against late blight.

DUSTING THE SEEDBED

About ten days after a long rainy period in early June, 1923, bacterial blight was found on very young plants in several seedbeds. Parts of each of two seedbeds on different farms were accordingly dusted with 20-80 copper lime. Three applications were made to one bed and two to the other, at seven-day intervals. In transplanting to the fields, plants from the dusted parts of the beds were set in several rows through the centers of the fields. During the last week in July, after the plants had become established, the fields were carefully inspected for diseased plants. In one field, out of 1,000 plants which had been dusted twice in the seedbed, 39 showed blight spots, while of an equal number of plants from the untreated part of the seedbed, 154 were found to be diseased. In the second field, out of 1100 plants which had been dusted three times in the seedbed, only 13 showed blight spots, while of an equal number from the untreated part of the seedbed 290 diseased plants were observed.⁹ Thus in one instance there were four, and in the other twenty-two, times as many focal points from which blight could be disseminated in those parts of the fields which had been set with plants from the untreated parts of the seedbeds. Both of these seedbeds had been located where celery had been grown for several years in succession.

It should be mentioned that in two other experiments there was no such evident benefit from dusting part of each of the seedbeds. Blight did not develop in these fields to any extent. The reason seemed to lie in the fact that these beds were located on land presumably free from blight, and the seedlings were all healthy when transplanted to the fields. No injury was observed in any seedbed from the use of 20-80 copper-

⁹ Only bacterial blight was noted in the seedbed, but after the plants were set out in the field a severe infestation of late blight occurred. The entire field was dusted throughout the season. Plants which had been dusted in the seedbed yielded 15 per cent more than those from the untreated parts of the bed. This gave a difference in yield of 45 crates an acre.



FIGURE 8. AN ADVANCED STAGE OF BACTERIAL BLIGHT ON A YOUNG CELERY PLANT IN THE SEEDBED

This specimen was collected in July, 1923, from a bed located on new muck, 300 feet from the nearest celery land. The same man, however, cared both for this and for several heavily infested seedbeds, and thus probably acted as a mechanical carrier of the blight pathogene. (Enlarged approximately twice)

lime dust, even though dusting was commenced when the plants had acquired only their first pair of true leaves.

Setting healthy seedlings of course does not always insure obtaining a disease-free crop, but it does delay the time of primary infection in the field, which is very important. Therefore, the seedbed should be located on clean land whenever possible, and, as a precaution against seed-borne blights, the young plants should be dusted or sprayed several times before being transplanted to the field. This is particularly important in fighting late blight, since *Septoria* is so common'y carried on the seed.

DISCUSSION

During six years (1917-1923), twenty-eight separate experiments were performed. In most of the experimental plots, hand sprayers and dusters were employed. In nine experiments, however, the plots were large enough to cover an entire field, and on these power outfits were used and the work was performed mainly by the regular farm help. A total number of 1,354,645 blight spots were counted on over 2000 plants during this time.

It was very evident that the sulfur fungicides are worthless for the control of the bacterial blight of celery, while those containing copper are very effective. The amount of copper seems to be an important factor in both liquid and dust. Less than 2.5 pounds of copper to the acre at each application gave inferior control in all instances. The upper limit of safety for copper concentration has not been accurately determined for either the liquid or the dust. Limited experiments in 1923, however, have indicated that under certain conditions very little more burning of celery leaves results from the use of a 30-70 or even of a 40-60 copper-lime dust than from a 20-80 mixture. The amount of burning seems to depend largely, however, on the weather, on the prevalence of insect or other injuries, and on the general vigor of the plants. Even a 20-80 copper-lime mixture or a 5-5-50 bordeaux mixture may injure the plants somewhat during periods of drought and heavy dews, if the plants have already been injured by the attacks of sucking insects, such as the tarnished plant bug. The tendency in recent years has been toward higher copper concentration, for this effects an economy for each unit of copper to both manufacturer and user. Although the 15-85 copper-lime dust was used throughout the fifth year of these experiments for the sake of uniformity, since then the 20-80 mixture has given very satisfactory control when used at from 30 to 45 pounds to the acre, and has come into general use.

Dry bordeaux mixture and bordeaux pastes, in our rather limited experience with them, gave more variable, and on the whole less satisfactory, results than either liquid bordeaux mixture or copper-lime dust. They have the advantage of convenience, and, when used at sufficient strengths with respect to copper content, gave fairly satisfactory control. At such strengths, however, they were expensive, though now they are not much more so than ready-mixed copper-lime dust. Bordeaux mixture made from them did not remain in suspension nearly so long as did homemade

bordeaux mixture. This is of some importance, for it means that the agitator should be kept in motion without interruption while spraying, which is rarely done in actual practice, particularly with a traction outfit. Adherence to the leaves was likewise inferior when the commercial bordeaux mixtures were used.

While the addition of a resin-fish-oil sticker to the 5-5-50 bordeaux mixture did not seem to give any better control of bacterial blight, nevertheless it may be said that where it was used the plants appeared more thoroughly covered after the second or third application. Some buyers prefer to purchase celery which has very evidently received a thorough coating of fungicide, because they know it will keep better than untreated celery. At the rate used, 4 pounds per 100 gallons of bordeaux mixture, the resin-fish-oil sticker has excellent adhesive qualities and possibly also acts as a spreader. No tests to determine this point, however, were made. In this connection it was very apparent, after the third application of dust, that plants dusted while still wet with dew retained a heavier coating than did those dusted later in the day, after they had dried. The dehydrated copper sulfate and hydrated lime unite to form a layer of colloidal membranes in the presence of moisture. As the plants dry off, this apparently sticks to the surface of the leaf practically as well as when the mixture is sprayed on to dry plants in the sunshine. The blight control and the general appearance of plants sprayed with 5-5-50 bordeaux mixture and of plants dusted with its equivalent of copper-lime dust while the dew was still on them were practically the same. Plants dusted while dry, however, appeared less thoroughly covered throughout the season and were less effectively protected from blight.

The choice between morning and evening as the best time to dust is largely a personal matter. The morning was chosen for these experiments as a matter of convenience and to insure completion of the work before the weather had time to change. It is true that shortly after sunrise air currents are sometimes induced which tend to carry the dust upward and away. At night, atmospheric conditions are often more favorable and improve after dark. At that time the dust hangs close to the ground, drifting back and forth for hours, and this results in a very heavy coating and an economy in the use of dust which is highly desirable. Dusting in the evening, commencing at six or seven o'clock or as soon as it is calm, and sometimes using a searchlight or two after dark, is becoming more and more popular with fruit growers; but celery dusting is done much later in the season, when the evenings have become much shorter. Most celery growers, therefore, are dusting in the morning. There is often a calm for one or two hours after sunrise, before the dew has dried off, which gives sufficient time for the average grower to cover his acreage.

Growers who do not wish to dust at night and who have large acreages to cover, thus necessitating dusting over a large part of the day, regardless of atmospheric conditions, have found that loss of dust from wind may be lessened, and better coverage obtained, by dragging a piece of light canvas behind the duster. This cloth is usually of light duck,



FIGURE 9. A DUST APRON IN OPERATION

This apron is attached to the boom of a four-row, power crop duster

and extends from one end of the boom to the other, amply covering four rows (figures 9 and 10). It should extend back from twelve to twenty feet, in order to confine the dust about the plants as long as possible. Weights are sometimes employed at proper intervals to hold the canvas down at the edges. Some one must carry this skirt, or apron, around at



FIGURE 10. A DUST APRON ROLLED UP WHEN NOT IN USE

the ends of the rows. Some growers drop an additional cloth screen in front of the nozzles, to eliminate troublesome air currents.

The time to dust or spray is, of course, just before a rainy period rather than just after, for it is during such periods that pathogenic organisms are disseminated and that the plants need protection. If the spray mixture has had time to dry for even a short time, the material will not be washed off to a serious extent. It is also better, whenever possible, to time field operations so that cultivation follows, rather than just precedes, dusting or spraying. This is particularly true when horse-drawn machines are employed, because just after cultivation the loose surface muck is more readily kicked up and scattered over the plant by the feet of the horses drawing the duster or spray rig. Whenever this muck remains on the leaves, they do not receive an adequate coating of fungicide. Furthermore, this soil may harbor the blight pathogenes, and thus place them in direct contact with the celery. There is, thus, much less danger of disseminating the pathogenes when dusting or spraying is done just before cultivation; and if a hand duster is being used, it is, of course, easier walking for the operator.

The question has often been asked as to the amount of celery that can be taken care of properly by a hand duster or blower gun. No two growers would exactly agree on the answer, but it is safe to say that one man using a hand-operated duster with two nozzles on it would have little difficulty in keeping as much as four acres thoroughly covered with dust in a season of normal rainfall. He could cover two acres in one morning before the dew disappeared, or in the evening, and two more the next day. One can usually count on two quiet mornings with plenty of dew, out of each week, and as many suitable evenings.

In the past, growers have had no choice between a hand duster and a large, four-row power rig. More recently, there has been some tendency on the part of manufacturers to consider the needs of the grower with moderate-sized fields, and to develop a traction duster of moderate price to cover two rows at a time. The tendency in duster manufacture is not in the direction of larger machines with more than eight nozzles, for there seems to be difficulty in getting efficient distribution and in keeping the machine reasonably light. Lightness is an important factor, particularly in a season of frequent rains, when it may be very important to make an application before the muck has really dried out sufficiently to escape the danger of the outfit getting mired. At such times a hand duster may be invaluable. It is almost as efficient in the hands of the average man as the larger power dusters.

The relative merits of dusting and spraying as a means of controlling celery blight are obvious. The advantages of dusting may be very briefly summarized. This method is much quicker and more convenient. Thirty acres a day may be covered with a four-row duster when only twenty can be sprayed. It is more convenient, since there are no stock solutions to be prepared beforehand and no paste or powder or crystals to weigh out or to dissolve. Not having to carry any water, the machine is lighter, and can sometimes be used at a critical time when it is important to make an application but when either "the well is dry" or there would be

danger of getting a heavy spray rig mired. There is less bother and delay from clogging and breakage of parts subject to high pressure. Hand-operated dusting machines are lighter to carry and easier to operate than similar sprayers. This makes dusting of seedbeds a very easy matter, and many growers will dust who would not bother to prepare a small amount of liquid and spray.

The chief disadvantage of dusting is that it is more expensive. However, it costs little more than spraying with commercial bordeaux mixture made from paste or powder. The dust costs from two to three times as much as the materials with which bordeaux mixture is made. This greater expense for materials is partly offset by the time saved by dusting. The larger the acreage, or the more times the spray rig would have to drive in and be filled, the more time will be saved by dusting, which eliminates such interruptions. Homenixing of dust would cut the price almost in two, but most growers are reluctant to buy a mixer and go to this trouble. It is a very simple task, however, and when done on a community basis is one of the easiest ways to effect a real economy.

There was some indication, in one experiment in a very dry season, that celery which was sprayed with bordeaux mixture or dusted with copper-lime dust suffered less from drought. The plants had a more healthy green color and were taller. However, no yields were obtained. This tendency to remain green longer when treated with copper fungicides is directly in line with the well-known facts in regard to potatoes similarly treated.

It should not be inferred from the results obtained in these experiments that dust necessarily will give a blight control much superior to that obtained by spraying. The man who obtained good control by spraying intelligently will get equally good control by dusting, if he does that intelligently. The man who dusts or sprays in a haphazard, hit-or-miss fashion, neglecting the seedbed, letting blight get well established in the field, or making his applications after rains instead of before, will get very poor results with either method.

GENERAL RECOMMENDATIONS

It is recommended that only good seed that has been tested the previous season for purity, viability, and freedom from disease be used.

Seed should be sowed in a well-drained, clean seedbed that has a good moisture supply, and should be dusted with 20-80 copper-lime dust two or three times at least before it is transplanted to the field. In a rainy season it may be advisable to dust several times in the seedbed, commencing when the plants have developed their first pair of true leaves or are about an inch high. This will lessen the likelihood of introducing seed- and soil-borne diseases into the field, and will often delay the time of primary blight infection. It is the simplest, easiest, cheapest kind of insurance, and often pays exceedingly well.

Applications of spray or dust should, in general, be made at weekly intervals throughout the growing season after the plants have been set in the field, and should be begun when the plants are about six or eight inches tall and continued until the last banking operations. During

periods of very frequent rains, or whenever blight seems to be increasing, it is highly desirable to make two, or even three, applications at about three-day intervals. The grower should, however, always be guided by intelligence rather than by rule of thumb. He should consider the previous history of his field and of his seedbed, as well as the rainfall, heavy dews, and the resistance to blight of the variety he grows. These factors all help determine to what extent he will have to protect his crop against blight. If these considerations are not all understood, the only safe rule to follow is to keep the plants thoroughly covered all the time. In the field this will require about 100 gallons of 5-5-50 bordeaux mixture to the acre at each application, or from 30 to 45 pounds of 20-80 copper-lime dust. When the plants are small, one nozzle to the row is sufficient; but after they are 9 or 10 inches tall two nozzles should be employed, in order to protect the lower, side leaves. Advantage should be taken of favorable atmospheric conditions whenever possible, but when it is dry and windy a canvas skirt attached to the rear of the duster may be found useful.

Cultivation should, as far as possible, follow dusting or spraying, and should be confined to times when the plants are dry, in order to avoid carrying from plant to plant the bacteria or spores of the pathogenes of blights.

Plants badly blighted at harvest time should not be trimmed in the field. But if it is not convenient to do the trimming and packing away from the field, the trash should at least be removed and burned as soon as possible,—not left on the field to be plowed under. A rotation should be practiced in which celery does not occupy the land two years in succession, particularly if blight occurs to an appreciable extent, because the blight pathogenes live over in the soil on the trimmings from diseased plants.

COST OF SPRAYING AND DUSTING¹⁰

The following schedules are offered as an approximation of the cost of spraying and dusting operations. They are based on actual experience in Wayne County, New York, under fairly typical conditions, but it must be borne in mind that labor costs and operating time vary considerably on different farms. In general, twenty acres can be sprayed in a day by two men and a team, with a four-row sprayer. One man and a team can dust three acres an hour with a four-row duster. On this basis, the cost of labor to the acre, at \$3 a day for the man and \$5 for the team, would be 55 cents for spraying and 26 cents for dusting. At 10 cents a pound for copper sulfate and 1 cent for lime, the cost of materials per acre for 100 gallons of homemade 5-5-50 is \$1.10. Therefore spraying costs per acre amount to:

Labor	\$.55
Materials	1.10
Total cost per acre	\$1.65

If, in place of homemade 5-5-50 bordeaux mixture, a commercial paste or powder is used, the cost of materials varies. When these experiments

¹⁰ Prices of both dry and liquid proprietary fungicides have lowered materially since this bulletin was prepared (June, 1923).

were performed, a 6-per-cent paste could be bought for 14 cents a pound. It required 40 pounds of this paste in 100 gallons of water to equal 100 gallons of 5-5-50, which means a cost of \$5.88 an acre for material. It is now (June, 1923) possible to buy a 22-per-cent dry bordeaux mixture at 20 cents a pound, or a 12-per-cent powder at 12 cents a pound, which would mean a cost, for materials, of only \$2.30 an acre. Therefore, spraying costs with these more convenient forms of bordeaux mixture amount to:

Labor	\$.55
Materials	2.30

Total cost per acre..... \$2.85

A 20-80 copper-lime dust, ready to use, can be purchased in the neighborhood of 8 cents a pound, which, at 35 pounds to the acre, will cost \$2.80. Therefore, the cost per acre of dusting with ready-mixed 20-80 copper-lime dust amounts to:

Labor	\$.26
Materials	2.80

Total cost per acre..... \$3.06

If the ingredients are bought separately, at 21 cents a pound for monohydrated copper sulfate and 1 cent a pound for hydrated lime, the cost a pound, including the labor of mixing, amounts to approximately 5 cents. Therefore, the cost per acre of dusting with 35 pounds of home-mixed 20-80 copper-lime dust is only:

Labor	\$.26
Materials (including cost of mixing).....	1.75

Total cost per acre..... \$2.01

The total cost for seven applications is, then, approximately \$12 an acre for spraying with homemade 5-5-50 bordeaux mixture, \$14 for home-mixed 20-80 copper-lime dust, and \$20 for either prepared dry bordeaux mixture or ready-mixed copper-lime dust. With a yield of 300 crates an acre, this only amounts to from 4.0 to 6.5 cents a crate.

DOES IT PAY TO CONTROL BLIGHT?

In some years a crop of celery is ruined by blight. There is no question but what protection pays well in such seasons. Furthermore, from the data obtained in these experiments, we are led to conclude that, even in years of very moderate blight development, one may obtain increases in yield of from 60 to 130 crates an acre by either spraying or dusting six or seven times. At \$2 a crate, which is slightly below the last five-year-average price of New York celery, the gross return on an investment of less than \$20 an acre is seen to be from \$120 to \$260 an acre.

Disregarding increases in yield, and figuring from the standpoint of quality only, it is well known that blighted celery brings less than clean celery. It would be conservative to put this difference in price at from 20 to 50 cents a crate, according to the amount of blight and the market price. With a yield of 300 crates per acre, the cost for labor and materials is not over 4 to 7 cents a crate. If a depreciation of 10 per cent on a machinery investment of \$400 is added to this and the cost spread over only 5 acres, the total cost for controlling blight for an entire season is, then, only from 6.5 to 9.5 cents a crate. Can any grower afford not to control his celery blight at such a low annual cost?

SUMMARY

1. Bacterial blight of celery cannot be controlled by sulfur fungicides.
2. The copper fungicides are very effective in the control of this disease, in the form of either sprays or dusts. Bordeaux mixture 5-5-50 and copper-lime dust 15-85 proved the most efficient of several substances tried, over a period of five years. (A 20-80 copper-lime dust is now used.)
3. Substantial increases in yields were obtained both by dusting and by spraying. The increases amounted to from 60 to 130 crates an acre when from five to seven applications were made.
4. Dusting while the plants were moist with dew gave a more lasting coating and a superior blight control than dusting when they were dry.
5. Proprietary compounds were not so effective in controlling blight as 5-5-50 bordeaux mixture, unless used at equivalent strengths with respect to copper content, and at these strengths they were considerably more expensive.
6. The addition of resin-fish-oil sticker, 2 pounds to 50 gallons, to homemade bordeaux did not give better blight control.
7. Hand-operated machines gave control comparable to that obtained with power machines.
8. Copper-lime dust cost nearly twice as much as did homemade bordeaux mixture. The initial cost of materials was somewhat offset by the decreased time required to cover a given acreage and by the elimination of considerable labor. When figured on a crate basis, the difference between the total cost of spraying and of dusting amounted to only 3 cents a crate less for spraying with homemade bordeaux mixture.
9. Under certain circumstances it paid well to make three applications of 20-80 copper-lime dust to plants in the seedbed, particularly when late blight was present.

APPENDIX

TABLE 1. SUMMARY OF THE AMOUNT OF BACTERIAL BLIGHT ON A SERIES OF 24 PLOTS, AFTER SIX APPLICATIONS OF 5-5-50 BORDEAUX MIXTURE AND OF 15-85 COPPER-LIME DUST BY HAND-OPERATED MACHINES.

(Tuttle and Russell farm, 1921. Figure 5 and page 16)

	Six check plots	Central check row in each of nine sprayed plots	Nine sprayed plots	Nine dusted plots
Number of blight spots per 10 plants in each plot.....	4,835 6,636 5,209 6,601 8,384 6,477	2,456 4,093 4,650 5,566 5,726 6,834 5,168	1,263 1,868 1,822 2,103 1,589 2,063 2,775	1,531 1,375 1,848 1,569 1,312 1,220 1,038
Total number of blight spots on 60 plants.....	38,142	4,812 4,016	1,377 2,517	1,209 2,268
Total number of blight spots on 90 plants.....	.....	44,321	17,377	13,370
Average number of blight spots per plant.....	635	492	193	149
Per cent of blight reduction....	.....	.....	70	76

TABLE 2. SUMMARY OF THE AMOUNT OF BACTERIAL BLIGHT ON A SERIES OF 36 ONE-SIXTH-ACRE PLOTS, AFTER FIVE APPLICATIONS OF 5-5-50 BORDEAUX MIXTURE AND 15-85 COPPER-LIME DUST BY POWER MACHINES

(Leenhouts Brothers farm, 1921. Figures 6 and 7)

	Twelve check plots	Twelve sprayed plots	Twelve dusted plots
Number of blight spots on blocks of 10 plants in each of 12 plots.....	1,984 1,688 3,239 1,571 3,446 4,388 1,396 4,752 4,269 4,411 3,390 3,267	752 635 1,032 639 85 165 254 196 499 553 534 579	775 729 587 688 422 34 73 21 157 364 524 311
Total number of blight spots on 120 plants..	37,801	5,923	4,994
Average number of blight spots per plant...	315	49	42
Per cent of blight reduction.....	.....	84	86

TABLE 3. SUMMARY OF EXPERIMENTS FOR TWO SEASONS, ON FOURTEEN FARMS, IN THE CONTROL OF BACTERIAL BLIGHT OF CELERY, COMPARING 5-5-50 BORDEAUX MIXTURE WITH 15-85 COPPER-LIME DUST*

Year	Farm	Number of applications	Total number of plants counted	Number of blight spots per plant			Per cent of blight reduction	
				Check	Spray	Dust	Spray	Dust
1920	Charles Mason.....	7	30	450	60	166	86	63
1921	Tuttle and Russell...	6	270	492	193	147	70	76
1921	Van der Post.....	4	90	507	126	107	75	79
1921	Glenn Beach.....	5	90	377	92	48	70	83
1921	J. D. Ameele.....	5	30	300	10	24	94	87
1920	Charles Mason.....	5	30	1,313	114	....	91	....
1920	Charles Mason.....	7	30	1,313	....	82	....	93
1920	Leenhouts Brothers..	5	30	1,614	37	....	98	....
1920	Leenhouts Brothers..	7	30	1,614	....	72	....	95
1921	Leenhouts Brothers..	5	360	315	49	41	84	86
1921	Leenhouts Brothers, farm 2.....	4	80	486	....	116	....	76
1921	Glenn Beach.....	4	240	454	....	76	....	83
1921	Colburn Brothers....	6	120	707	90	70	77	90
1921	M. L. Fikes.....	7	240	591	44	27	92	95

* Power machines were used in all but the first five experiments.

TABLE 4. COMPARATIVE YIELDS OF CELERY SPRAYED WITH 5-5-50 BORDEAUX MIXTURE AND DUSTED WITH 15-85 COPPER-LIME DUST*

Farm and year	Number of applications	Yields per acre						Per cent of increase over untreated	
		Untreated		Sprayed		Dusted		Spray	Dust
		Pounds	Crates	Pounds	Crates	Pounds	Crates		
Tuttle and Russell, 1917	7	27,984	310	34,000	377	.....	.....	15	.....
Charles Mason, 1920...	7	55,680	618	68,800	764	69,960	777	23	25
Charles Mason, 1920...	5	54,180	602	60,750	675	.....	.....	12	.....
Charles Mason, 1920...	7	54,180	602	.....	.....	66,420	738	.....	23
M. L. Fikes, 1921.....	7	39,390	463	45,030	529	55,890	551	14	19

* Power machines were used in the last three experiments.

TABLE 5. THE VALUE OF DUSTING WHEN THE PLANTS ARE MOIST WITH DEW, AS SHOWN BY THE RELATIVE AMOUNTS OF BLIGHT ON THE TWO PARTS OF EACH OF EIGHT DUSTED PLOTS

(Tuttle and Russell farm)

	Dusted when plants were moist with dew	Dusted when plants were dry	Untreated
Number of blight spots on blocks of 5 plants in each of 8 plots.....	675 663 434 283 640 610 619 391	1,593 546 604 937 672 1,238 948 984	... ... ... ... ... ... ... ...
Total number of blight spots on 40 plants..	4,315	7,522	...
Average number of blight spots per plant...	107	188	635

TABLE 6. RELATIVE AMOUNTS OF BLIGHT ON THE TWO PARTS OF THREE DUSTED PLOTS

(Glenn Beach farm)

	Dusted when plants were moist with dew	Dusted when plants were dry	Untreated
Number of blight spots on blocks of 5 plants in each of 3 plots.....	307 93 189	291 280 275	... ... ...
Total number of blight spots on 15 plants...	589	846	...
Average number of blight spots per plant...	39	56	377

